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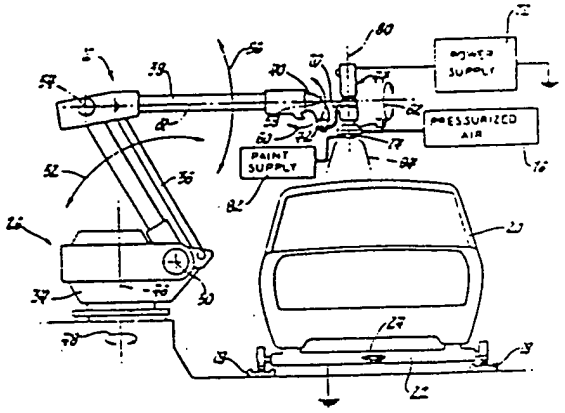
(54) Method of painting an automobile body.

(57) A method of painting an automobile body 20 utilises a robot painting system 10 for electrostatically painting the automobile body, the system including a paint module 12 adapted to maintain the automobile body in a stationary position relative to at least two painting robots 26 to 30, each of which carries a rotary bell-type atomizing device 74 and provides programmed movement thereof about five control axes 46, 50, 54, 58, 61 at a speed which prevents the cone-shaped pattern 84 of atomized paint particles from being distorted due to any gyroscopic effect developed by the atomizing device as it is moved about the control axes.



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METHOD OF PAINTING AN AUTOMOBILE BODY

This invention relates to a method of painting an automobile body as specified in the preamble of claim 1, for example as disclosed in US-A-3,279,421.

Over the years, the painting of automobiles in production plants has evolved from the use of relatively inefficient conventional air-type spray guns operated manually or by a mechanical reciprocator to the use of electrostatic air-spray guns and electrostatic rotary atomizing devices, which have appreciably increased paint transfer efficiency. One problem, however, with the electrostatic paint apparatus and methods currently used for painting automobile bodies is that, during the painting process, the bodies are carried by a high-speed conveyor which moves the bodies through a long paint booth that houses a plurality of pre-positioned large, cumbersome rotary atomizing devices or a plurality of robots fitted with air-spray guns.

It has been found that when the automobile body passes through a paint booth using the robot air-spray guns, the paint transfer efficiency is about 30 per cent, and approximately 35 per cent of the vehicle body is painted. This can be attributed to a number of factors, not least the use of high-pressure air for atomizing the paint, together with the relative movement of the body and the air guns. Even if the vehicle body is maintained stationary so that 100 per cent of the body can be painted, the transfer efficiency of a robot air-spray gun system has been found to be no more than about 40 per cent. As a result, additional paint stations must be located along the production line for touch-up and painting of the remaining 65 per cent of the body.

Paint systems in which the automobile body is painted by prepositioned rotary atomizing devices permit improved transfer efficiency up to approximately 80 per cent as the body moves through the spray booth, and paint coverage of

about 65 per cent of the body, but this type of paint system is not considered entirely satisfactory because additional paint stations are still required to provide complete coverage of the body.

As a result, a need has existed for a new and improved paint system and method which would not only provide high efficiency in paint transfer but also eliminate the need for additional paint stations currently required for providing full coverage of the automobile body.

This need is met by the measures specified in the characterising portion of claim 1.

By the use of a method in accordance with the present invention,electrostatic paint transfer efficiency of the order of 80 per cent, as well as 100 per cent body coverage, can be obtained with a robot system consisting of two or more programme-controlled robots, each of which has at least five degrees of freedom, carries a light-weight miniature rotary bell-type atomizing device, and moves the atomizing device at only a small fraction of standard painting speeds.

In a preferred form of a method in accordance with the present invention, the entire painting process is performed with the automobile body maintained stationary, and the bell of the atomizing device is rotated at a speed which causes mechanical atomization of liquid paint supplied to the bell. In addition, during atomization of the liquid paint, an electrostatic field is created between the atomizing device and the automobile body that causes the atomized paint particles to be directed from the atomizing device to the automobile body in a cone-shaped pattern, and the speed of movement of the atomizing device about the five axes is controlled so as to prevent the cone pattern of the paint particles from being disturbed or distorted by any gyroscopic effect which may be created by the high-speed rotating bell as it is moved to different positions along

a path that follows the surface contours of the body.

The miniature high-speed rotating bell-type atomizing device that causes mechanical atomization of the liquid paint is readily movable along interior and exterior irregular surface contours of the automobile body at a predetermined distance therefrom and at a relatively slow speed which is preferably not greater than 0.43 metres/second (1.4 feet/second).

The support head is preferably programme-controlled.

In the drawing:

Figure 1 is a plan view of an automobile body located in a paint module and being painted by a robot painting system using a method in accordance with the present invention; and

Figure 2 is an enlarged view on the line 2-2 of Figure 1, and shows an elevational side view of one of the robots utilized in the robot painting system for electrostatically painting a stationary automobile body using a method in accordance with the present invention.

As is shown in Figures 1 and 2 of the drawing, a robot painting system 10 includes a paint module 12 having an entrance end 14 and an exit end 16 and provided with a track 18 along which an automobile body 20 is conveyed into and out of the paint module 12 by a wheeled carrier 22 connected to a power-driven conveyor chain 24. The paint module 12 serves as a spray booth which includes laterally spaced side walls 13 and 13' and a roof (not shown); in the preferred form, both the entrance end 14 and the exit end 16 of the paint module 12 can be automatically closed by doors (not shown) so as to provide a completely sealed chamber within which the automobile body 20 can be painted while in a stationary position by four painting robots 26, 28, 30 and 32 located within the paint module 12.

One advantage of using a paint module 12 such as that described is that the problem of overspray on to other bodies is eliminated, and consequently a lower air velocity is adequate for removing fumes and non-deposited atomized paint particles from the interior of the module 12. Each of the painting robots 26 to 32 is identical in construction, and the portion of each robot located in the paint module is constructed with explosion-proof structure so as to allow the robot to operate safely during the painting operation.

More specifically, and as is seen in Figure 2, each of the robots 26 to 32 is a five-axis hydraulically-operated unit which includes a base 34, a primary arm 36, a secondary arm 38, and a wrist 40 that terminates with a support head 42 which, in this case, supports an atomizing device 44. Each of the robots 26 to 32 is suitable for programme-controlled movement to achieve universal work processing relationships with the automobile body 20. Programme control is achieved by the use of a robot-control unit (not shown) which will be located outside the paint module 12 and will include a built-in microcomputer for selectively actuating hydraulic drive means (not shown) operatively associated with the base 34, primary arm 36, secondary arm 38 and wrist 40 for achieving prescribed movements of the atomizing device 44 about the five control axes.

In detail, the base 34 is supported for controlled rotation about a first axis 46 in a rotary path 48, and the primary arm 36 is movable about a pivotal connection which provides a second axis 50 and movement in a curved path 52. The secondary arm 38 is pivotally supported at the upper end of the primary arm 36, and is movable about a pivotal connection which provides a third axis 54 and movement in a curved path 56. The wrist 40 is supported at the free end of the secondary arm 38, and carries the support head 42, which is movable relative to the secondary

arm 38 about a fourth axis 58 allowing movement in the curved path 60, and which is also rotatable about a fifth axis constituted by the longitudinal axis 61 of the secondary arm 38, in the rotary path 62.

Control of each of the robots 26 to 32 is effected by means of a computer-based supervisory controller 64, which is capable of receiving various electrical input signals and generating output signals for initiating the operation of the robots in accordance with a pre-programmed sequence of operation. The controller 64 is connected to a limit switch 66 which, when tripped, indicates to the controller 64 that the automobile body 20 has reached a predetermined position within the paint module relative to the robots 26 to 32. The controller 64 also controls the supply of electricity to an electric motor 68 which drives the conveyor chain 24, as will be more fully explained.

Robots providing programmed control movement about multi-axes as described above are commercially available, and two models, either one of which can be used in practising this invention, are Model OM5000 manufactured by Grayco Robotics Inc., 12898 Westmore Avenue, Livonia, Michigan 48150, U.S.A. and Model HPR-1 manufactured by Hitachi Limited, Tokyo, Japan and available through Interrad Corporation, 65 Harvard Avenue, Stamford, Connecticut, 06902, U.S.A.

The atomizing device 44 is connected by means of a bracket 70 to the support head 42 of the wrist 40, and includes a body portion which consists of a high-voltage generator 72 and a high-speed bell 74 capable of rotating at speeds up to 30,000 RPM. A source 76 of pressurized air is connected to an air turbine drive 78 for rotating the bell 74 about the longitudinal axis 80 of the body portion of the atomizing device 44. During the high-speed rotation of the bell 74, liquid paint is fed to the bell 74 from a paint reservoir 82 at a flow rate of approximately 350 cubic centimetres per minute, and is mechanically

atomized by the rotating bell. The bell is connected by way of the high voltage generator 72 to a power supply which normally is at a voltage of 24 volts, this voltage being increased by the high voltage generator 72 to a value of 72 to 100,000 volts which is needed to electrostatically transfer the atomized paint particles to the grounded vehicle body 20. The electrostatic field created between the bell 74 and the automobile body 20 should be of sufficient intensity to achieve the desired electrostatic deposition. The electrostatic field serves to form the charged atomized paint particles into a cone-shaped pattern 84 which can be varied in diameter by means of conventional air-shaping ports (not shown) formed in the atomizing device 44. An atomizing device 44 of the type described above is manufactured by the aforementioned Interrad Corporation, and is identified as Model PPH-307.

Prior to the painting operation, an automobile body, such as the body 20, is located in the paint module 12 in a predetermined position, and the control unit of each of the robots 26 to 32 is placed in a "teach" mode, at which time the atomizing device 44 associated with each robot is manually moved along the surface of the body, with the axis 80 being maintained substantially perpendicular to the particular area of the automobile body to be coated. Inasmuch as the atomizing device 44 is movable about the aforementioned five control axes, the atomizing device 44 of each robot can follow a path which permits it to paint the roof and the associated side panels, and also to enter the interior of the engine compartment and trunk to paint normally hidden areas of the body. As is seen in Figures 1 and 2, the automobile body 20 is of a size and configuration comparable to a General Motors Corporation "X" body. After the movement of the atomizing device 44 of each of the robots 26 to 32 has been programmed, the robot painting system 10 is ready to paint a succession of bodies in a manner which will now be described.

In practising the invention, the automobile body 20 can initially pass a model recognition detector (not shown) which sends a signal to the controller 64, which in turn will command the robots 26 to 32 to select the particular programme for the body concerned. The body 20 is then conveyed into the paint module 12, moving through the entrance end 14 and continuing to be moved by the chain 24 until it trips lever 86 of limit switch 66, which then causes the controller 64 to discontinue energization of the drive motor 68. At this point, the automobile body 20 is located in the exact position it assumed during the "teach" mode. The controller 64 then commands each of the robots 26 to 32 to start its particular programme for electrostatically painting the exterior and the interior portions of the automobile body 20 while the latter is maintained in the stationary position. Each robot then provides movement of its atomizing device 44 about the five control axes.

Inasmuch as the bell 74 rotates at a high RPM about the longitudinal axis 80 of the atomizing device 44, certain movements of the atomizing device 44, such as movement in the rotary path 62, will cause a force reaction to be applied to the head support 42 of the robot. This force reaction will tend to prevent such movement, and will be referred to herein as gyroscopic effect (gyroprecession). The gyroscopic effect can, if strong enough, cause the atomizing device 44 to experience erratic shaking movement which will cause the cone-shaped pattern 84 of the atomized paint (created by the electrostatic field) to be distorted, resulting in poor transfer efficiency and low-quality coverage. It has been determined, however, that by having the atomizing device 44 weigh no more than five kilograms (eleven pounds), providing a bell with a diameter at the discharge edge of approximately 51 millimetres (2 inches) or somewhat less, and having the atomizing device 44 move relative to the

body at an average speed no greater than 0.43 metres/second (1.4 feet/second), the proper cone-shaped pattern 84 can be maintained and good quality painting achieved.

During a test using the aforementioned Model PPH-307 Interrad atomizing device, which weighs 2.5 kilograms (5.5 pounds) and has a bell having a discharge edge diameter of approximately 51 millimetres (2 inches), in combination with the Model HPR-1 Hitachi robot, it was established that with this particular combination, if used in a robot painting system in conformity with the present invention, and having the support head 42 move relative to the body being painted at an average speed of approximately 254 millimetres per second (10 inches per second), a paint transfer efficiency of 80 per cent can be attained, and 100 per cent of the body can be painted.

After the robots have completed their programmed movement relative to the automobile body 20, a signal is given to the controller 64, which in turn causes energization of the electric motor 68 for causing the automobile body to be conveyed out of the paint module, and another automobile body is then brought into the paint module 12 and the painting operation is repeated.

Although four robots are shown as being used in the robot paint system 10, the entire automobile body 20 could if required be painted using two robots only. For example, if the robots 28 and 30 (only) were located in the paint module 12 in the positions shown in Figure 1, then with the automobile body 20 properly positioned, the front half of the body 20 would be painted by these robots 28 and 30. Afterwards, these robots 28 and 30 could be repositioned along a horizontal track or the like to the positions normally occupied by the robots 26 and 32, to paint the rear half of the automobile body 20. In this manner, two of the robots shown could be eliminated, and still the entire vehicle could be painted in accordance with the present invention.

The method as described in accordance with the invention improves the efficiency of paint transfer, and provides an improved finish on the automobile body. The method makes it possible to achieve 100 per cent coverage of the automobile body, so eliminating the need for "touch-up" paint stations.

Claims:

1. A method of painting an automobile body by the use of an electrostatic spray coating system utilising translatable rotating heads (74) for atomizing paint to be deposited on the automobile body (20), characterised in that the method is carried out with a robot system (10) which includes a paint module (12) having at least two robots (26 to 30) located therein and each of said robots having an arm (38) provided with a support head (42) movable about five control axes (46 etc), and a bell-type atomizing device (74) attached to the support head (42) and adapted to rotate about a spin axis (80), and that the method comprises:

a. conveying (chain 24) the automobile body (20) into the paint module (12);

b. locating (switch 66) the automobile body (20) in a predetermined stationary position in the paint module (12);

c. rotating (drive 78) the bell (74) of the atomizing device about the spin axis (80) at a speed sufficient to mechanically atomize a liquid paint supplied to the interior of the bell (74);

d. creating (generator 72) an electrostatic field between the rotating bell (74) and the automobile body (20) for causing the atomized liquid paint to be directed from the rotating bell (74) to the automobile body in a cone-shaped pattern (84); and

e. moving (controller 64) the rotating bell (74) at a speed which will prevent any gyroscopic effect developed by the rotating bell (74) from distorting the cone-shaped pattern (84) as the bell (74) is moved about the five control axes (46 etc.).

2. A method according to claim 1, characterised in that the robot system (10) with which the method is carried out comprises at least two programme-controlled robots (26) as aforesaid located within the paint module (12), each of the robots (26) having an arm (38) as aforesaid provided with a support head (42) as aforesaid which is movable about the five control axes (46 etc.), means (24,66) for conveying the automobile body (20) into the paint module (12) and for locating the automobile body (20) in a stationary and predetermined position relative to the robots (26) during the painting of the automobile body (20), a bell-type atomizing device (74) as aforesaid mounted on the support head (42) of the arm (38) and having a sufficiently small size to enable the atomizing device (74) to apply paint to hidden surfaces of the automobile body (20) and to be inserted within inner compartment areas of the automobile body (20), means (78) for rotating the bell (74) of the atomizing device (44) about its spin axis (80) at a speed which causes mechanical atomization of liquid paint supplied to the atomizing device (44), means (72) for creating an electrostatic field between the bell (74) of the atomizing device and the automobile body (20) for causing the atomized liquid paint to be directed from the atomizing device to the automobile body (20) in a cone-shaped pattern (84), and control means (64) for causing the support head (42) of the arm (38) to move the atomizing device (44) about the five control axes (46 etc.) at a speed which, due to the said small size of the atomizing device (74) in conjunction with the action of the robot (26), will prevent any gyroscopic effect from distorting the cone-shaped pattern (84) due to movement of the atomizing device (44) about the five control axes (46 etc.).

3. A method according to claim 1 or 2, utilising at least two robots (26) as aforesaid, characterised in that in step b. the automobile body (20) is located in the said predetermined position relative to the robots (26) and is maintained in the said predetermined position, in step c. the bell (74) of the atomizing device of each of the robots (26) is rotated about its spin axis (80) at a speed between 20,000 and 30,000 RPM, and in step e. the bell (74) is moved along the vertically oriented and horizontally oriented surfaces of the automobile body (20) at the said speed which will prevent any gyroscopic effect developed by the rotating bell (74) from distorting the cone-shaped pattern (84) as the bell (74) is moved about the five control axes (46 etc.), in proper orientation relative to the said surfaces.

4. A method according to claim 3, characterised in that the bell (74) is moving along the vertically and horizontally oriented surfaces at a speed no greater than 0.43 metres/second (1.4 feet/second).

5. A method according to any one of claims 1 to 4 characterised in that doors leading into and out of the paint module (12) are closed after the automobile body (20) is positioned within the paint module (12).

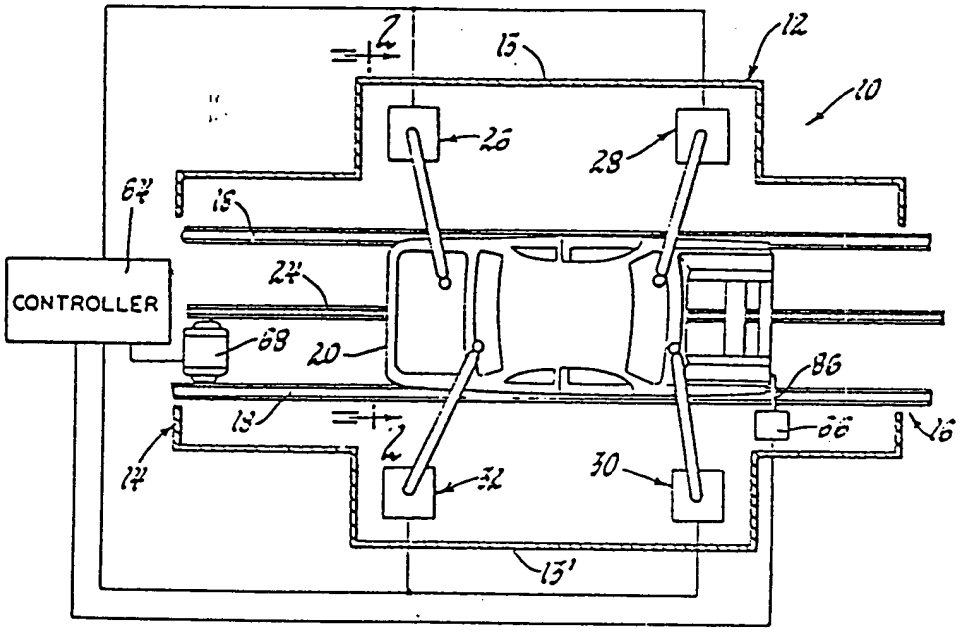

Fig. 1

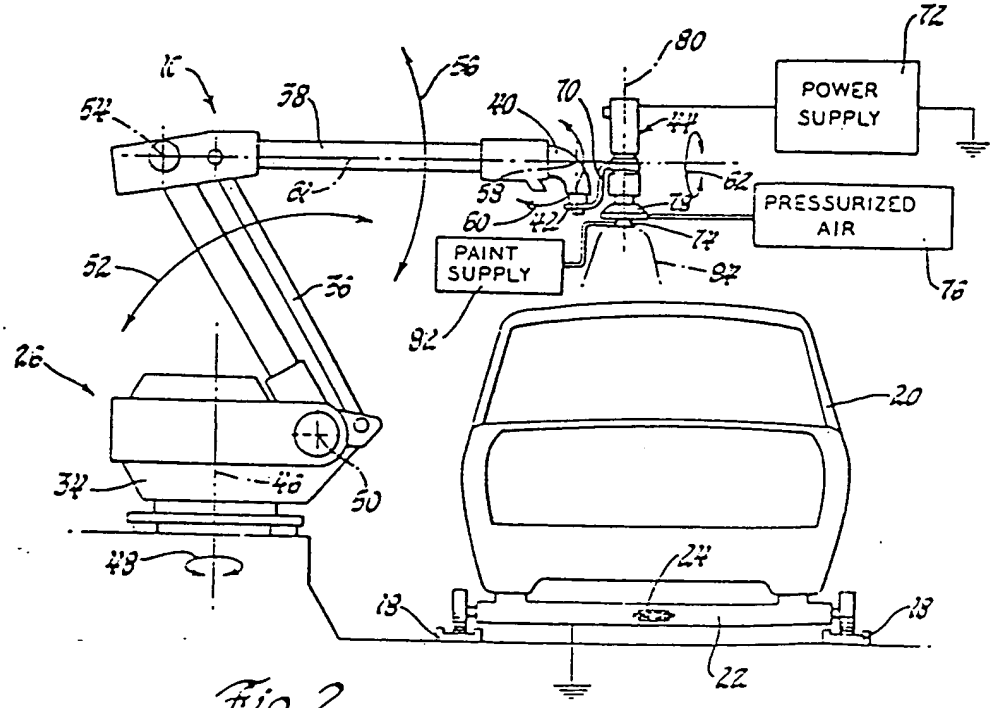

Fig. 2

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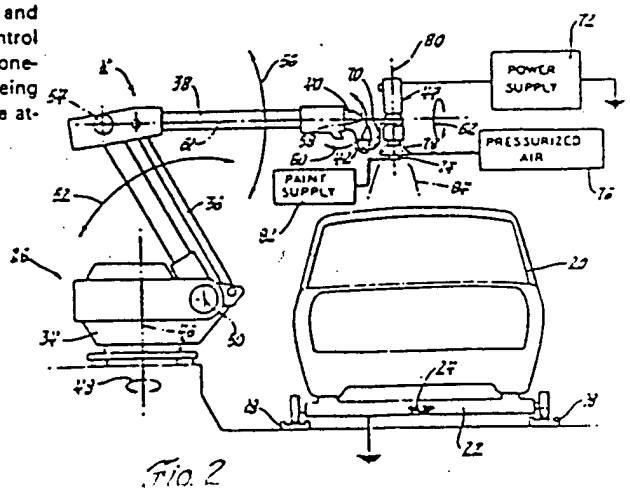

Fig. 2

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European Patent Office

EUROPEAN SEARCH REPORT

0122034

Application number

DOCUMENTS CONSIDERED TO BE RELEVANT

EP 84301542.1

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.³)
D,A	US - A - 3 279 421 (TILNEY AND CAMPBELL) * Claims; fig. *		B 05 B 13/04 B 05 B 5/04 B 05 D 1/04

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

B 05 B
B 05 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	30-08-1985	SCHÜTZ

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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